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AN EMBRYONIC PLESIOSAURIAN PROPODIAL.

By Roy L. Moodie, University of Kansas.

OUR conception of the morphology of vertebrate limb bones is much complicated by the conditions found in the propodials of embryonic and young plesiosaurs. Examples of these bones are not at all rare in the Cretaceous deposits of the West, and there are several references to them in the literature, including a few discussions of the characters which they present. Doctor Williston has especially dwelt upon the characters of a very immature plesiosaurian limb bone which he discovered in the chalk of western Kansas. He also figured examples of other, more mature, propodials (Field Museum, Publication 73, plates 22 and 23, 1903). The writer later referred to the immature element and described others in an attempt to arrive at some conclusions in regard to the morphology of the so-called epiphyses of the plesiosaurs (Amer. Journn. Anat., vol. VII, No. 4, p. 443, 1908). The conclusions reached pointed definitely to the fact that the so-called epiphyses of plesiosaurs, turtles and dinosaurs are in reality the endochondral ossifications of the limb bones, and differ in all structural respects from true epiphyses.

The conditions which complicate our conceptions of the morphology of the vertebrate limb bones are the presence of numerous grooves and foramina in many places on certain types of plesiosaurian propodials. These grooves and canals are especially well marked in the specimen which is described herewith.

There has been in the museum of the University of Kansas for some time a small embryonic plesiosaurian propodial which I suppose to represent a humerus. It is as immature as any propodial known to me, with the exception of the small one described by Doctor Williston. Judging from the matrix still adhering to the specimen, it is from the Niobrara Cretaceous, but just what locality is not known, though probably somewhere in western Kansas. The element presents most peculiar and unusual characters, which are believed to be new to our knowledge of plesiosaurian anatomy. The character which is especially striking is the deep, well-marked groove on the radial (?) side. It forms, save for a small pathological interruption, a shallow, smooth-bottomed trough which extends fully half around the periphery. On the opposite edge there is a very shallow groove which is not nearly so well marked as the one described above. Its bottom is rough and has the openings of at least three distinct foramina, with many smaller vascular openings.

It has been observed that the structure of the immature plesiosaurian propodial is more dense than is the case in fully matured bones. This holds true for the present specimen. The density of the embryonic propodial is undoubtedly due to the fact that the bone cells have not yet become vascularized. This dense condition of the perichondrium is not confined to the bones of plesiosaurs, since the same characters are found in the limb bones of young alligators and lizards.

The presence of the grooves and foramina appears to be peculiar to the plesiosaurian propodial. The writer has examined, during the past few months, the embryonic skeletal systems of numerous specimens of several species of turtles, lizards and the American alligator. In none of these has he been able to distinguish any structure which could be correlated with the grooves and foramina found in the plesiosaurian propodial, but it has been observed that the structure of the perichondrium is more dense in the embryonic limb bones than in the bones of the adults of the same species. The exterior surfaces are smooth. Possibly the degrees of density of the limb bones of vertebrates is to be correlated with the rate of growth of the animal. It is a matter of easy observation that different immature plesiosaurian propodials offer different degrees of density of structure even among the embryonic bones. The above-mentioned foramina and grooves have not been described, so far as I am aware, in the limb bones of any adult vertebrate, recent or extinct.

The present example of plesiosaurian propodial measures 83 mm. in length by 31 mm. in width. It tapers somewhat at each end, with the greater width at the distal end. There is a distinct roughening of the surface in several places, near the edges, which do not have the same characters as the muscular roughenings of the adults, but seem to be due to blood vessels in the caps of cartilage which undoubtedly covered the ends and sides of the bone.

The deep groove, present on one edge of the bone, is peculiar both in its extent and width. It has hitherto not been observed on immature plesiosaurian limb bones. It fills nearly the entire radial (?) edge. Its edges are sharply defined and its bottom is marked by numerous small and a few large vascular pits, giving the surface a punctate appearance. Somewhat more than half beyond the length of the bone distally there is a large, rough tuberosity, probably due to some disease or accident, as it is very vascular, like most exostosial growths. It recalls, for instance, the pathological growth known as the "lump-jaw" of cattle, which is familiar to travelers on the western plains. This pathological interruption occupies 15 mm. of the bottom of the groove. It lies just over the opening of a rather large canal, which gives passage to a calcite-filled cavity in the center of the bone. This cavity is paralleled by the condition found in the more mature propodial shown in figures 8 and 9.

Grooves of a similar nature have been observed on more mature material. There are examples of several adult and immature propodials in the collection which show these grooves, and a few of them show the foramina as well, as is shown in figures 4, 5, 6, and 7. Three foramina are shown in figure 4 and one in figure 9. In the adult and less mature propodials the grooves never extend the entire length of the bone, but are restricted to the distal one-third, or, at most, to the distal half. In five specimens there are grooves present on both edges of the bone, as shown in one instance in figures 4 and 5.

The pits and foramina opening into the canals which pass to the internal cavities usually occur on the edge opposite the groove, but occasionally they occur on the same edge, and in case the groove is present on both edges the foramina are present at times on both edges also. The specimen outlined in figure 4 has the grooves on both edges. On the edge represented in figure 5 there is a single foramen, while on the edge shown in figure 4 there occur three foramina. The specimen outlined in figure 6 shows no pits at all, and the groove occurs only on the edge where it is figured. The adult bone of figure 7 has no pits and the groove is confined to one edge.

The meaning of these various grooves, foramina, pits, etc., is rather difficult to perceive. Judging from the condition found in the embryonic bone described above, one might be correct in saying that there were two ossific centers for the perichondral bone. But there are immature propodials and mature ones which show not the slightest signs of the pits, grooves or foramina, nor, on sectioning, does any evidence of the internal cavity appear. So far as I am aware, all propodials which exhibit these structures belong in the genus *Polycotylus.* I do not recall that they have ever been detected in bones assigned to *Elasmosaurus*, *Trinacromerum* or *Plesiosaurus.* Certainly there are no evidences of them in the propodials of these genera which are accessible. And, oddly enough, they do not occur in all examples of *Polycotylus*, for they are not found in the propodial associated with a nearly complete paddle of *Polycotylus latipinnis* Cope, which is, I believe, regarded by Doctor Williston as a hind paddle. This seems to mean that the above-mentioned characters are confined to the humerus, which only serves to complicate our bewilderment. It has been suggested that the pits, canals and cavities corresponded to similar structures in other vertebrate limb bones where the pits and canals give passage to blood vessels, and the internal cavity corresponded with the medullary cavity. This may well be true, but we still have to explain the presence of this peculiar groove which is so highly developed on the present embryonic plesiosaurian propodial.

EXPLANATION OF FIGURES.

FIG. 1. Dorsal view of the embryonic plesiosaurian propodial. The groove will be seen on the right side of the figure. X 1.

FIG. 2. Edge of the embryonic propodial, to show the shallow groove. X ⅖.

FIG. 3. Edge of the embryonic propodial, to show the deep groove. X ⅖.

FIG. 4. Edge of more mature propodial, showing an elongate groove and three foramina. X ⅖.

FIG. 5. Opposite edge of distal end of propodial figured in 4.

FIG. 6. Edge of a worn, nearly mature propodial of *Polycotylus*. X ⅖.

FIG. 7. Edge of a mature propodial of *Polycotylus*, showing the elongate fissure at the distal end on one edge. X ⅖.

FIG. 8. Section through a mature propodial of an undescribed plesiosaur. X ½.

FIG. 9. Lateral view of same propodial shown in figure 8. A=foramen shown at A in figure 8. X ½.

PLATE I. A series of plesiosaurian propodials, showing the evolution of the shape of the bone. Two genera, *Polycotylus* and *Elasmosaurus*, are possibly represented. Not all the bones figured show the pits, grooves and canals. The small white nodule above the row at the right is a so-called "epiphysis" belonging to an immature plesiosaurian propodial. The embryonic bone described above is the last of the series to the right. X ¼.

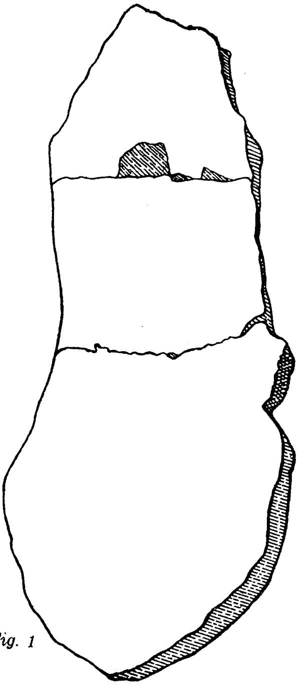

Fig. 1

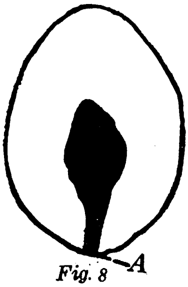

Fig. 8

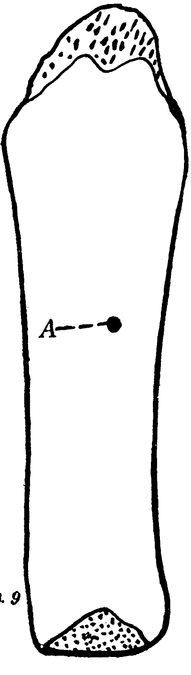

Fig. 9

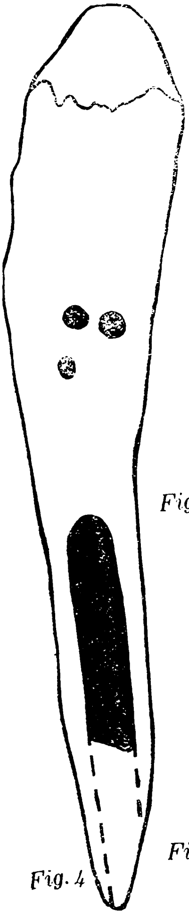

Fig. 4

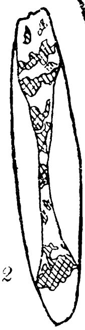

Fig. 2

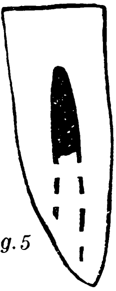

Fig. 5

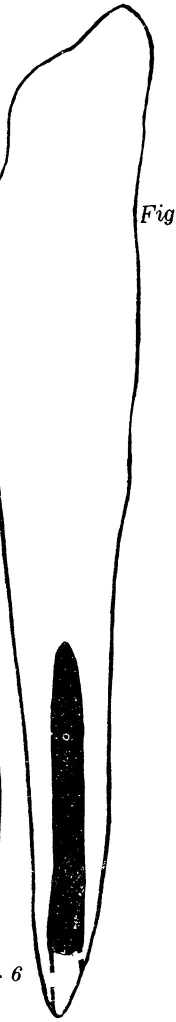

Fig. 6

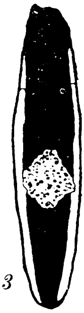

Fig. 3

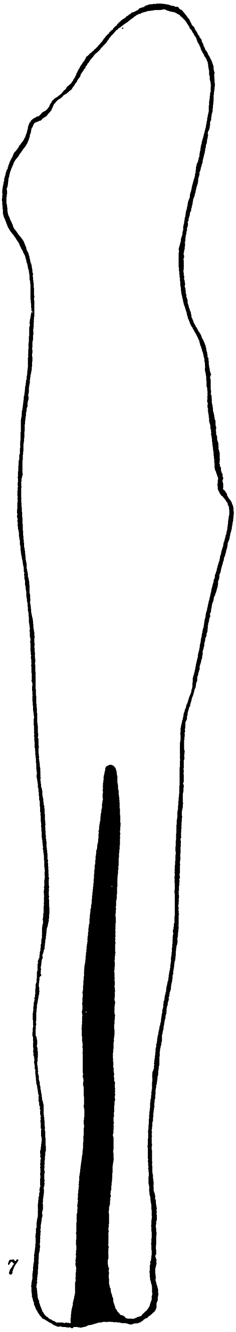

Fig. 7

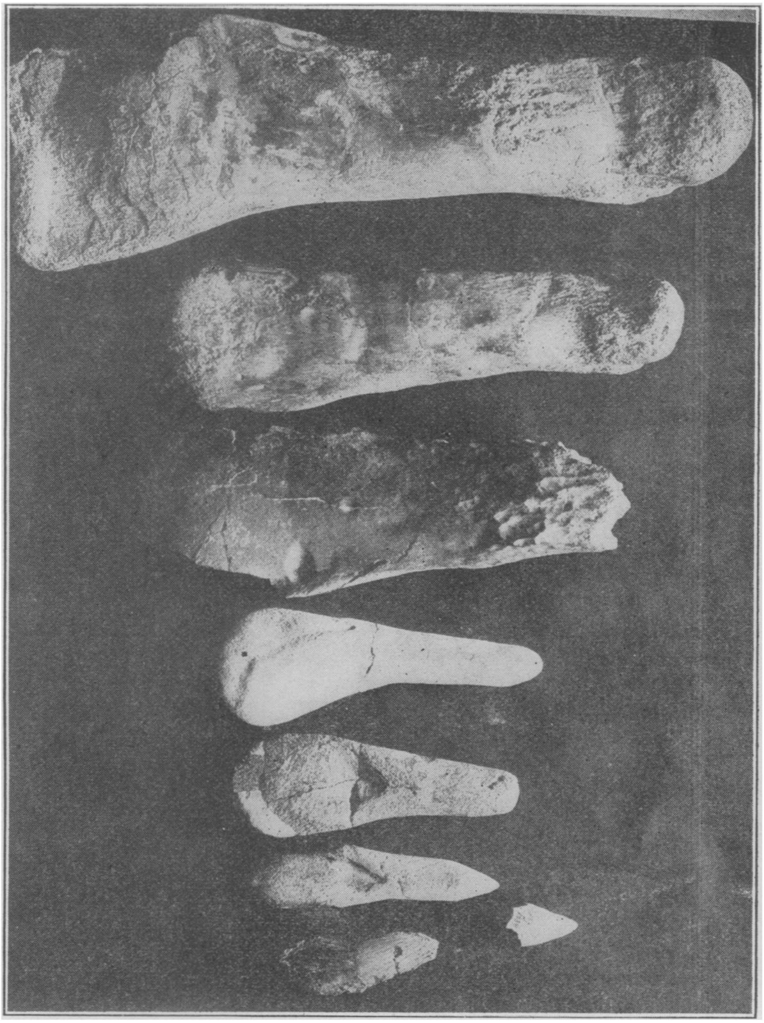

PLATE I.